# Trunk-enabled Toys

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## Abstract
This work explores the use of technology to help create different kinds of interfaces for controls aimed at captive elephants, enabling them to interact with digitally enhanced playful systems (smart toys). The focus of the paper is on current participatory design sessions with an elephant and her keepers, giving rise to insights on species-specific interfaces and how to enable playful encounters with technology.

## Author Keywords
ACI; elephant; physical computing; prototype, games; toys; interaction; tangible interface; environmental enrichment.

## ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## Introduction
Wild animals have to make decisions all the time - where to go, what to eat, who to socialise with - but their captive counterparts are often in situations where they have little control over their lives because routine husbandry takes care of everything. However, there is a growing consensus [1] [2] [3] that offering captive animals more control over their environment is enriching for them and contributes to their welfare.

### Importance of play for captive animals

Play is an important part of normal development in animals (Goodenough 2009). As it is a voluntary activity (Brown and Vaughan 2010), it enables free expression. For captive animals, play is a hallmark of good welfare (Kingston-Jones 2014, Oliveira et al 2010).

Play for captive animals could be enabled through toys or games. Toys are designed for freeform play, whereas games are structured and require understanding of rules (Callois 1961). Toys are intrinsically cognitively enriching (Spinka et al 2001), and all mammal and bird species can benefit from such freeform enrichment (Young 2003), but dealing with constraint and uncertainty is what makes games fun (Costikyan, 2013).

This research is exploring the design of playful, interactive systems that offer captive elephants choice and control, thereby providing them with sensory and cognitive enrichment.

Because elephants are so different from humans with regard to their behaviour, physiology and cognitive abilities, the design of such a system raises significant challenges. Investigating how to resolve these challenges may lead to a deeper understanding of the animal and could potentially also lead to innovation in interaction design methodologies.

## Research Methods

We are trying to accomplish two things – (i) to find out how an elephant is best able to control a system using her natural modalities and behaviours; (ii) to find out what kind of feedback a system might offer that has some intrinsic reward, such that she chooses to engage with it voluntarily.

To tackle these questions, we have firstly tried to appreciate the elephant as a potential user, by synthesising existing knowledge on lifestyle, behaviour and cognition. Secondly, to gain a greater understanding of captive elephants and their carers in context, we have undertaken multi-species ethnographic studies of captive elephants living in the UK, as advocated by other ACI (Animal Computer Interaction) researchers [4] [5]. Thirdly, we have conducted interviews with experts in the field, including members of the Elephant Welfare Group [6], enrichment specialists (from The Shape of Enrichment organisation [7]), zoo keepers (Colchester Zoo, Howletts Wild Animal Park, Blair Drummond Safari Park) and academics.

Having established some elephant requirements [8], we are currently developing prototypes for toys that will promote some natural behaviour patterns and offer sensory and cognitive enrichment. We are initially working with Valli, a female Asian elephant at Skanda Vale Ashram [9], who is one of our beta-testers. We are using a flavour of participatory design called "bodystorming" [10] the goal of which is to be able to investigate users with their tools or systems in the context (physical space) in which they will be used.

Initial concepts were discussed with domain experts, whose advice was invaluable. Nevertheless, it has been during the prototyping stage that we have begun to truly appreciate the possibilities and limitations of the task.

Participatory game design has recently been investigated in the context of serious games (games that aim to promote knowledge or skill acquisition in their players) [11]. The authors conclude that the usual methods for including players in the design process are complicated by the fact that designers of serious games also need to be domain experts and that players might not have the meta-skills to be able to analyse their own learning experiences.

This is relevant for us, because game designers working on concepts for animals are unlikely to be domain experts, this being the field of zoologists. It is therefore necessary to be able to work closely with the people who are domain experts (typically keepers).

Of equal importance is the fact that the players themselves will be unaware of being part of a game design process.

Figure 1: Valli with sewing machine pedal button

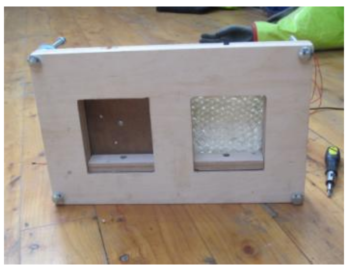

Figure 2: Vibrotactile buttons

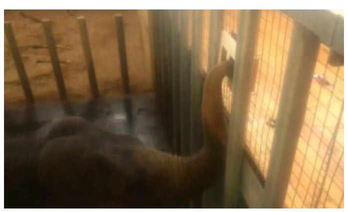

Figure 3: Valli tests vibrotactile buttons

We make many assumptions about how humans can evaluate a system (they know it is a manufactured product, they will have interacted with other systems before etc), but these cannot be applied to an animal, for whom technology is an utterly mysterious phenomenon. In other words, humans appreciate that they are testing a man-made game and can offer feedback based on this implicit knowledge. Even when fully engaged with a system and in a state of flow [12], a typical person still knows she is having a technology mediated experience. Animals, on the other hand, perceive the world in a natural way and have no concept of the underlying technology.

This raises questions about the most appropriate ways of obtaining feedback on prototype designs from the target user - an elephant. So far, we have relied on keepers interpretations of Valli's behaviour and the efficacy of the control systems (was she able to use them effectively, with support?). We plan to integrate data collection within the system software to gain a better understanding of how she uses the systems when keepers and visitors are not present.

## Prototyping with Valli

As Valli is a single, orphaned elephant who grew up with humans and still has the company of her human keepers, one of the experiences missing from her life is the companionship of other elephants. An example of some natural communication between wild elephants is antiphonal calling, which involves call and response patterns within the herd. As a result, we decided to introduce some audio experiences that Valli could control independently, invoking an acoustic response from the system.

During our early sessions, we played her some samples of low frequency audio, using ranges that approximate to the low frequency rumbles emitted by elephants calling to each other (ranging from 20-100Hz). We established that low frequency samples would not cause distress and identified a possible frequency range (60-70Hz) to explore with future systems [13]. However, elephant rumbles have a complex waveform, and the samples were simple sine waves, so we subsequently used samples of instruments that generate complex waveforms including low frequency sounds, such as tuba, didgeridoo and contra-bassoon.

We felt it was important that Valli was able to take control of any acoustic system introduced to her enclosure, rather than being the passive recipient of our audio choices. Therefore, it was time to focus on the interface she might be able to use.

We have tested a range of simple buttons with Valli, using different materials and sensors [13]. The main interface design challenges have been: (i) materials and construction; (ii) location (iii) control feedback mechanism; (iv) sensor activation.

## Conclusions

*Materials and construction*

Buttons in the traditional human format (push-to-make) were less successful, because they did not map to an elephant's natural behavioural tendencies. Controls that were manufactured with tactile appeal for an elephant (corrugated pipes, textured surfaces) worked well because Valli was interested in exploring them with her trunk. Our latest prototypes were constructed from natural textiles (smooth rope and

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woven hessian), fixed securely in a wooden frame. (See Figure 2)

The controls have to be able to withstand an elephant's natural curiosity and strength. One option might have been to construct the casing in a tough material like steel, but we have opted instead to explore softer, natural materials and use the position of the device to mitigate against destructive tendencies.

*Location*

The position of a control system is critical because elephants are easily able to destroy objects made from natural materials.

Initially, we located the device behind a browsing hole, so that it was only accessible to a trunk tip. One disadvantage of this was that the button location was far removed from any output, thereby making a cause and effect mapping unlikely. Also, a browsing hole is associated with foraging. We are keen to explore non-food enrichment, in order to find out what other sensory stimulation might be interesting for an elephant.

Secondly, we fixed the button just outside Valli's enclosure, fixed to the ceiling. While it was possible for her to touch this button, she could not see it and therefore had no motivation to explore a novel object.

Our most recent prototypes have been encased in wooden frames and bolted high on a balcony fence, where they are visible and accessible using trunk tip. There is the added advantage that speakers and other technology can be kept out of her reach, but close to the control, on the balcony, easily adjustable by a person. This is an aspect of design that is context-dependent, as different institutions will have different environmental constraints.

*Control feedback*

Control systems usually offer intrinsic feedback to the user as well as instigating an output mechanism. We tested a large sewing machine pedal (See Figure 1), which sprang back after being pushed, but the most successful controls provided haptic feedback in the form of vibrating motors behind the contact area. The keepers agreed that Valli seemed interested in exploring these buttons. She spent some time feeling the distinct vibration patterns (See Figure 3).

*Sensor activation*

Hidden sensors have been successful, as they can detect trunk movement in close proximity to a button and do not rely on the elephant performing a specific action, such as pushing a lever or pulling a rope. While keepers believe that elephants are capable of learning such actions and could easily be motivated to do so, the construction of a suitably robust control with moving parts would be challenging. Our most recent prototype deployed PIR (passive infra-red) technology to sense an approaching trunk.

Our plans for further development will be focusing on vibrotactile controls with hidden sensors, offering control over aspects of environment including water supply and acoustic stimulation.

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